Claims 4, 5 and 7 are rejected under 35 U.S.C. 103 as being unpatentable over U.S. Patent 4,555,668 (Gregorian et al.) in view of U.S. Patent 5,892,540 (Kozlowski et al.). Claims 4, 5 and 7 are deemed allowable for reciting combinations forming a solid-state imaging device which includes, among other things, a variable gain amplifier wherein which sequentially receives a first and second signal voltages from a photoelectric conversion device. The first signal voltage represents an optical signal impinging on the photoelectric conversion device while the second voltage signal represents the initialized state of the photoelectric conversion device. The difference between the first and second voltage signals is output. Neither Gregorian et al. nor Kozlowski et al. suggest a variable amplifier receiving first and second signal voltages from a photoelectric conversion device wherein the first signal voltage represents the detected optical signal and the second signal voltage represents the initialization state of the photoelectric conversion device. Accordingly claims 4, 5 and 7 are clearly patentable.

Claims 6 and 8-10 are rejected under 35 U.S.C. 103 as being unpatentable over Kozlowski et al. in view of U.S. Patent 6,342,694 (Satoh).

Claim 6 recites, among other things, a plurality of photoelectric conversion devices arrayed in rows and columns, for converting the optical signals into the electric signals and for outputting a first signal voltage obtained by converting each optical signal into the corresponding electric signal and for outputting a second voltage obtained by initializing each corresponding photoelectric conversion device, along with a variable gain amplifier for

receiving the first and second signal voltages. Claims 8-10 recite methods wherein first and second electric signals are output from a photoelectric conversion device, the first electric signal representing the impinging optical signal and the second electric signal representing the initialized state of the photoelectric conversion device. Although Kozlowski et al. and Satoh employ reference voltages along with signal voltages representing optical signals, they do not teach or suggest the combinations of elements and steps in claims 6 and 8-10.

Claims 12 and 15 are rejected under 35 U.S.C. 102 as being anticipated by Kozlowski et al. Claim 12 is deemed allowable for reciting, among other things, a switching means provided between respective input sides of the amplifiers of at least two columns, for mixing the difference signals of at least two columns, and claim 15 is deemed allowable for reciting among other things, mixing the respective difference signals from the amplifiers of at least two columns in common input sides thereof. In Kozlowski et al. signals from two pixels are mixed by being provided with a part shown by symbol 90 in Fig. 1. However, the mixing is apparently performed on an output side of operation amplifier 22 in Fig. 1 and not at the common input sides of the amplifiers. Accordingly claims 12 and 15 are clearly novel and patentable.

Claims 13, 14 and 16 are deemed allowable for the same reason that claims 12 and 15 are allowable.

The application is now deemed in condition for allowance and such favorable action is requested.

Respectfully submitted,

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COPY OF AMENDED PARAGRAPHS AND CLAIMS SHOWING DELETIONS IN BRACKETS AND INSERTIONS BY UNDERLINING

Page 5, lines 4-12, — A variable gain amplifier of the present invention is characterized in that it converts a [fist] <u>first</u> signal voltage and a second signal voltage into charges by sequentially inputting the first and second signal voltages, generates a difference signal between the first and second signal voltages, amplifies the difference signal by a gain so as to set the difference signal within a requested range of a digital encoding analog input level, and outputs the difference signal.—

Page 17, lines 9-14, — The foregoing constituent components of the pixel 101 are covered with a light transmissive insulating film, and a region other than that of a [light-recieving] <u>light-receiving</u> window 24 of the photo diode 111 is shielded from a light by a metal layer (light shielding film) 23 formed on the insulating film.—

— 4 (Amended). A solid-state imaging device in which an optical signal is converted into an electric signal, the electric signal is converted into a digital signal, and the digital signal is outputted, comprising:

(a) a plurality of photoelectric conversion devices arrayed in rows and columns, for converting the optical signal into the electric signal and outputting a signal voltage;

(b) a variable gain amplifier provided for each of the columns, the variable gain amplifier including

(i) an input terminal of the variable gain amplifier for sequentially inputting a first signal voltage obtained from a corresponding photoelectric conversion device of the plurality of photoelectric conversion devices be converting an optical signal into an electric signal and a second signal voltage obtained by initializing the corresponding photoelectric conversion device,

(ii) an output terminal of the variable gain amplifier for outputting a difference signal between the first signal voltage and the second signal voltage,

(iii) an operational amplifier having a positive input terminal for inputting a reference voltage, a negative input terminal connected through a signal path to the input terminal of the variable gain amplifier, and an output terminal connected to the output terminal of the variable gain amplifier,

(iv) an input capacitor provided in the signal path extending from the input terminal of the variable gain amplifier to the negative input terminal of the operational amplifier, the input capacitor having one end connected through the signal path to the input terminal of the variable gain amplifier and having the other end connected through the signal path to the negative input terminal of the operational amplifier,

(v) a feedback capacitor having a variable capacitance [set variable,] provided between the negative input terminal and the output terminal of the operational amplifier,

(vi) a first switch device for connecting or disconnecting the signal path,

(vii) a second switch device for connecting or disconnecting an input of the reference voltage to the one end of the input capacitor, and

(viii) a third switch device for connecting or disconnecting the negative input terminal and the output terminal of the operational amplifier; and

(c) an analog/digital conversion circuit converting the difference signal outputted from variable gain amplifier into a digital signal.—

— 6 (Amended). A solid-state imaging device in which [an] optical [signal is] optical signals are converted into [an] corresponding electric [signal] signals, the electric [signal is] signals are converted into [a] corresponding digital [signal] signals, and the digital [signal is] signals are outputted, comprising:

a plurality of photoelectric conversion devices arrayed in rows and columns, for converting the optical [signal] signals into the electric [signal] signals and for outputting a first signal voltage obtained by converting each optical signal into the corresponding electric signal and for outputting a second voltage obtained by initializing each corresponding photoelectric conversion device;

a variable gain amplifier for sequentially inputting [a] <u>the</u> first signal voltage [obtained by converting an optical signal into the electric signal] and the second signal voltage [obtained by initializing the photoelectric conversion device], converting the first signal voltage and the second signal voltage into charges to generate [the] <u>a</u> difference signal therebetween, and adjusting a gain according to an amplitude of the difference signal to output the difference signal having an output level adjusted.—

— 8 (Amended)). An optical signal reading method for converting an optical signal into an electric signal, converting the electric signal into a digital signal, and then outputting the digital signal, the optical signal reading method comprising the steps of:

irradiating a photoelectric conversion device with an optical signal;

outputting a first signal voltage obtained by converting the optical signal into an electric signal;

converting the first signal voltage into charges and storing the charges;

outputting a second signal voltage at an initialization of the photoelectric conversion device <u>same as that obtaining the first signal voltage</u>;

converting the second signal voltage into charges;

generating a difference signal between the first signal voltage stored as the charges and the second signal voltage converted into the charges, adjusting a gain according to an

amplitude of the difference signal, and generating a difference signal having an output level adjusted; and

converting the difference signal having the output level adjusted into a digital signal.—

— 11. [The] An optical signal reading method [according to claim 10,] for converting an optical signal into an electric signal, converting the electric signal into a digital signal, and then outputting the digital signal, wherein

a plurality of the photoelectric conversion devices are arrayed in rows and columns, each of the photoelectric conversion devices including

(i) a photodetector, and

(ii) an insulated gate field effect transistor for optical signal detection provided adjacent to the photodetector, the insulated gate field effect transistor for optical signal detection including a heavily doped buried layer for storing photo-generated charges generated by the photodetector, the heavily doped buried layer being provided around a source region under a channel region below a gate electrode; and

[wherein] a variable gain amplifier is provided in each of the columns, the variable gain amplifier [includes] including

[(i)] (iii) an input terminal for sequentially inputting [the] a first signal voltage and [the] a second signal voltage,

[(ii)] (iv) an output terminal for outputting a difference signal between the first signal voltage and the second signal voltage,

[(iii)] (v) an operational amplifier having a positive input [terminal] for inputting a reference voltage, a negative input [terminal connected to an input terminal of an integrating circuit], and an output [terminal] connected to [an] the output terminal [of the integrating circuit],

[(iv)] (vi) an input capacitor provided in a signal path extending from the input terminal [of the integrating circuit] to the negative input [terminal] of the operational amplifier, the input capacitor having one end connected through the signal path to the input terminal [of the integrating circuit] and having the other end connected through the signal path to the negative input [terminal] of the operational amplifier,

[(v)] (vii) a feedback capacitor provided between the negative input [terminal] and the output [terminal] of the operational amplifier,

[(vi)] (viii) a first switch device for connecting/disconnecting a signal path extending from the input terminal [of the integrating circuit] to the one end of the input capacitor,

[(vii)] (ix) a second switch device for connecting/disconnecting [an input of] the reference voltage to the one end of the input capacitor, and

[(viii)] (x) a third switch device for connecting/disconnecting the negative input [terminal] and the output [terminal] of the operational amplifier[, and];

the optical signal reading method comprises the steps of:

(a) irradiating each photodetector with an optical signal;

[(a) adjusting a gain by adjusting a ratio of a feedback capacitance with respect to an input capacitance so as to set the difference signal within a requested range of an input voltage of an analog signal at converting the difference signal into the digital signal;]

(b) transferring photo-generated charges generated by the photodetector and storing them in the heavily doped buried layer of the insulated gate field effect transistor for optical signal detection, while connecting the second and third switch devices to initialize the input capacitor and the feedback capacitor;

(c) then, connecting the first and third switch devices, disconnecting the second switch device, outputting a signal voltage according to the photo-generated charges stored in the heavily doped buried layer from the insulated gate field effect transistor for optical signal detection, and then converting the signal voltage into charges and storing them in the input capacitor as [charges] the first signal voltage;

(d) then, connecting the second switch device and disconnecting the third switch device, so as to transfer the charges of the first signal voltage stored in the input capacitor to the feedback capacitor;

(e) then, discharging the photo-generated charges remaining in the heavily doped buried layer to initialize the photoelectric conversion device, thereafter connecting the first switch device, disconnecting the second and third switch devices, outputting [a second signal voltage in] the initialized state of the photoelectric conversion device from the insulated gate field effect transistor as the second signal voltage for optical signal detection, then converting the second signal voltage into charges, and storing a difference between the charges of the first signal voltage and the charges of the second signal voltage to generate the difference signal;

(f) converting the difference signal into a digital signal; and

[(f)] (g) then, adjusting a gain by adjusting a ratio of the input capacitor and the feedback capacitor so as to set the difference signal within a range of an analog input voltage which is converted into the digital signal, and outputting the difference signal having the output level adjusted from the operational amplifier to each of the columns.—

— 12 (Amended). A solid-state imaging device comprising:

a plurality of photoelectric conversion devices arrayed in rows and columns, for converting an optical signal into an electric signal and outputting the electric signal;

an amplifier provided for each of the columns, for sequentially inputting a first signal voltage obtained by converting the optical signal into the electric signal, and a second signal voltage obtained by initializing the photoelectric conversion device, for converting the first

signal voltage and the second signal voltage into charges, and for outputting a difference signal between the first signal voltage and the second signal voltage;

a video signal output terminal for outputting the difference signal outputted from the amplifier as a video signal corresponding to the optical signal; and

a switching means provided between respective input sides of the amplifiers of at least two columns, for mixing the difference signals of at least two columns.—

:

— 15 (Amended). An optical signal reading method of a solid-state imaging device which includes

(i) a plurality of photoelectric conversion devices arrayed in rows and columns, for converting an optical signal into an electric signal and for outputting the electric signal,

(ii) a plurality of amplifiers provided for the respective columns, each of the amplifiers being for sequentially inputting a first signal voltage obtained by converting the optical signal into the electric signal, and a second signal voltage obtained by initializing the photoelectric conversion device, for converting the first signal voltage and the second signal voltage into charges, and for outputting a difference signal therebetween, and

(iii) a video signal output terminal for outputting the difference signal outputted from the amplifier as a video signal corresponding to the optical signal,

the method comprising the steps of;

mixing the respective difference signals from the amplifiers of at least two columns in common input sides thereof; and

outputting an output signal from the amplifier.—

— 17 (Amended). [The] An optical signal reading method [according to claim 16,] of a solid-state imaging device which includes a plurality of photoelectric conversion devices arrayed in rows and columns for converting an optical signal into an electric signal and for outputting the electric signal, a plurality of amplifiers provided for the respective columns, each of the amplifiers for sequentially inputting a first signal voltage obtained by converting the optical signal into the electric signal, and a second signal voltage obtained by initializing the photoelectric conversion device, for converting the first signal voltage and the second signal voltage into charges, and for outputting a difference signal therebetween, and a video signal output terminal for outputting the difference signal outputted from the amplifier as a video signal corresponding to the optical signal, wherein

each of the photoelectric conversion devices includes

(i) a photodetector, and

(ii) an insulated gate field effect transistor for optical signal detection, provided adjacently to the photodetector, the insulated gate field effect transistor for optical signal detection including a heavily doped buried layer for storing photo-generated charges generated by the photodetector, the heavily doped buried layer being

provided around a source region under a channel region below a gate electrode, the first signal voltage and the second signal voltage are outputted from the source region of the insulated gate field effect transistor for optical signal detection;

[an] each amplifier [and a pixel mixing switch are provided in each of the columns, the amplifier includes] including

[(i)] (iii) an input terminal for sequentially inputting [a] the first signal voltage and [a] the second signal voltage,

[(ii)] (iv) an output terminal for outputting a difference signal between the first signal voltage and the second signal voltage,

[(iii)] (v) an operational amplifier having a positive input [terminal] for inputting a reference voltage, a negative input [terminal connected to an input terminal of the amplifier], and an output [terminal] connected to an output terminal of the amplifier,

[(iv)] (vi) an input capacitor provided in a signal path extending from the input terminal of the amplifier to the negative input [terminal] of the operational amplifier, the input capacitor having one end connected through the signal path to the input terminal of the amplifier and having the other end connected through the signal path to the negative input [terminal] of the operational amplifier,

[(v)] (vii) a feedback capacitor provided between the negative input [terminal] and the output [terminal] of the operational amplifier,

[(vi)] (viii) a first switch device for connecting/disconnecting the signal path,

[(vii)] (ix) a second switch device for connecting/disconnecting [an input of] the reference voltage to the one end of the input capacitor, and

[(viii)] (x) a third switch device for connecting/disconnecting the negative input [terminal] and the output [terminal] of the operational amplifier, and

[the] a pixel mixing switch device [connects] connecting the negative [input terminals] inputs of the operational amplifiers of at least two columns, [and]

the method comprises the steps of

(a) irradiating each photodetector with an optical signal;

(b) transferring photo-generated charges generated by the photodetector to the heavily doped buried layer of the insulated gate field effect transistor for optical signal detection and storing the charges therein, while connecting the second and third switch devices to initialize the input capacitor and the feedback capacitor;

(c) then, connecting the first and third switch devices, disconnecting the second switch device and the pixel mixing switch device, and thus outputting [a] the first signal voltage corresponding to the photo-generated charges stored in the heavily doped buried layer from the insulated gate field effect transistor for optical signal detection, and converting the first signal voltage into charges and storing the charges in the input capacitor;

(d) then, connecting the second switch device, disconnecting the third switch device, and thus transferring the charges of the first signal voltage stored in the input capacitor to the feedback capacitor; and

(e) then, discharging the photo-generated charge remaining in the heavily doped buried layer to initialize the photoelectric conversion device, thereafter connecting the first switch device and the pixel mixing switch device, disconnecting the second and third switch devices, outputting a second signal voltage in the initialized state of the photoelectric conversion device from the insulated gate field effect transistor for optical signal detection, thus converting the second signal voltage into charges and storing them in the input capacitor, then mixing the charges of the first signal voltages from the photoelectric conversion devices of at least two columns and the charges of the second signal voltage therefrom through the pixel mixing switch device connecting the negative input terminals of the operational amplifiers of the at least two columns, and then outputting an output signal from the operational amplifier.—